GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2000

Computer Aided Engineering
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

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The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

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COMPUTER AIDED ENGINEERING

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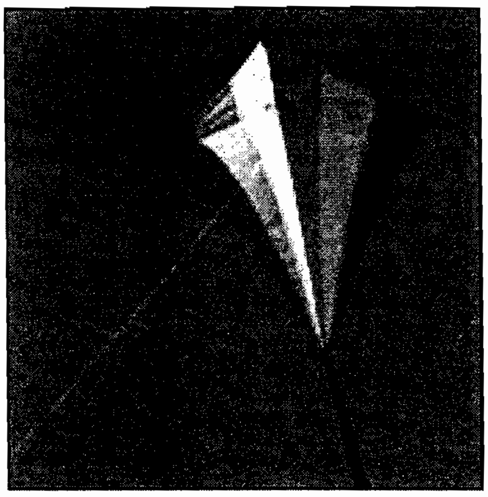
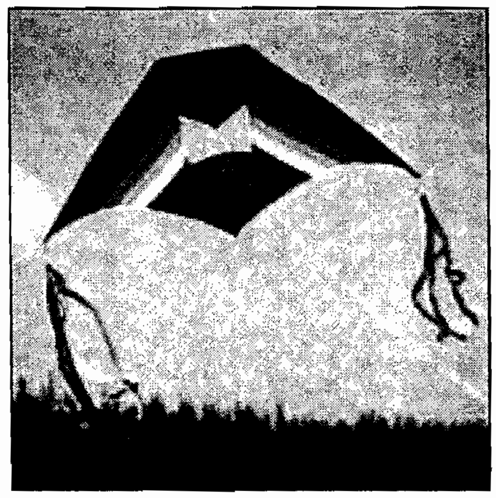
GEORGIA INSTITUTE OF TECHNOLOGY
GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEERING

COMPUTER-AIDED DESIGN
PH.D. QUALIFYING EXAM
Spring 2000

Well, springtime brings many things...the many windy days are perfect to go fly a kite. Kites come in many shapes and sizes. This exam will cover some of these.





We are interested in learning what you know and your ability to reason. If for some reason you do not follow the question or are confused, kindly adjust the question suitably and proceed with your answer. Please structure your answers as follows:

1) Restate the problem in your own words, identifying any assumptions, judgments, and adjustments that you are making.
2) Tell us your strategy or plan for solving this problem.
3) Solve the problem.
4) Tell us about any insight you gained by solving this problem.

Oral Exam Note

When you come to the oral exam be prepared to comment briefly on your research activities and where CAE/CAD technology fits into that research.

Question 1.

Given

Equations for **Bezier curves** are

$$b(u) = \sum_{j=0}^{n} B_{i,n}(u)\bar{P}$$

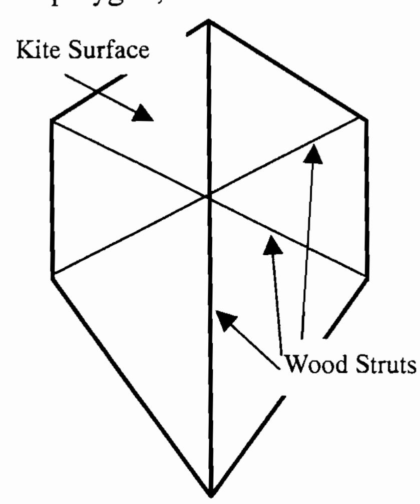
$$B_{i,n}(u) = \binom{n}{i} u^i (1-u)^{n-i}$$

where: **P** are the control vertices that define the Bezier curve.

Questions

a) Assume that you are given the following three control vertices for a planar quadratic Bezier curve: $\mathbf{P}_0$ = (0,1), $\mathbf{P}_1$ = (3,2), $\mathbf{P}_2$ = (3, -1). Sketch the control polygon, then sketch in the curve.

b) Compute the X,Y point on the curve at u = 0.5.



The three questions below deal with the kite shown to the right.

c) Sketch the front view of a kite with 6 sides, similar to the kite shown above. On your sketch, partition the kite surface into 4-sided surface patches. You need to achieve G^1 continuity between your patches.

d) What type of surface patch would you recommend to model the kite surface, using your model above? Justify your answer with at least three reasons, expressed qualitatively or quantitatively.

e) Either on a different sketch or on the sketch for part (c), draw in control vertices or other boundary conditions and explain how you will achieve G^1 continuity among your surface patches.

Question 2

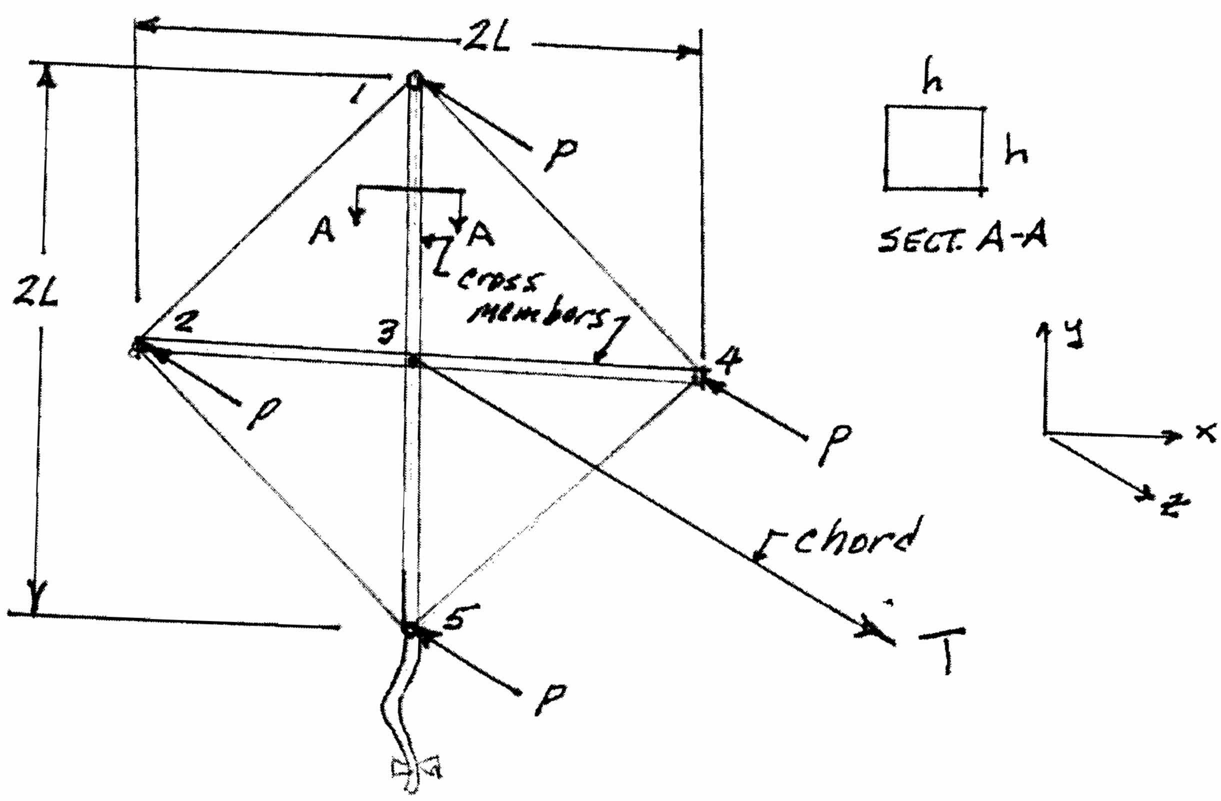
Assume you have a diamond shaped kite configuration with the chord having a tension T. Assume all wind forces P are concentrated at the ends of the braces and perpendicular to the kite surface.

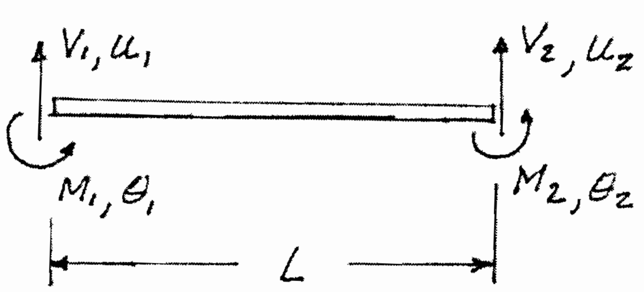
a) Develop a finite element model of the brace system for the applied forces.

b) How much do the cross member braces deflect at the ends due to wind forces?

c) What is the maximum stress at the critical point on the braces?

The cross-members are square with width H and Youngs Modulus E. The bending finite element stiffness of a beam is given below.





$$\begin{bmatrix} \frac{12EI}{L^3} & \frac{6EI}{L^2} & \frac{-12EI}{L^3} & \frac{6EI}{L^2} \\ \frac{6EI}{L^2} & \frac{4EI}{L} & \frac{-6EI}{L^2} & \frac{2EI}{L} \\ \frac{-12EI}{L^3} & \frac{-6EI}{L^2} & \frac{12EI}{L^3} & \frac{6EI}{L^2} \\ \frac{6EI}{L^2} & \frac{2EI}{L} & \frac{6EI}{L^2} & \frac{4EI}{L} \end{bmatrix} \begin{bmatrix} u_1 \\ \theta_1 \\ u_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ M_1 \\ V_2 \\ M_2 \end{bmatrix}$$

Question 3:

In flying a kite it is found that the force on the string (y, in Newtons) can be related to its length (x, in meters) by $y = ax^{(3+\frac{1}{x})} + b$. Experimental data showed that

x (m)	1	2	3	4
y (N)	7	1	5	3

Determine the values of "a" and "b" in the length-force relationship based on the least square error principle.